AMERICAN MUSEUM NOVITATES

Number 1015 Published by THE AMERICAN MUSEUM OF NATURAL HISTORY New York City February 20, 1939

FOSSIL PLANTS FROM THE UPPER CRETACEOUS AGUJA FORMATION OF TEXAS

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The collection of fossil plants here described is, to my knowledge, the first record of determinable leaf impressions from the Aguja formation of western Texas. Although small, the collection is unusual because of the fine state of preservation of a single large palm leaf. Scattered fragments of palm leaves are not uncommon in the Upper Cretaceous and Tertiary deposits of the northern hemisphere. The majority of specimens, however, are unfortunately neither as well preserved nor as complete as the Aguja specimen and are consequently not easily identified.

I am indebted to Dr. Barnum Brown for the opportunity to examine the collection at The American Museum of Natural History.

The large palm leaf was discovered in a sandstone ledge (Fig. 1) in the Tornillo Creek basin of Texas by Mr. H. E. Norton of Marathon. In August, 1936, Mr. G. D. Guadagni of Boston visited the area and succeeded in obtaining the palm leaf intact. Invertebrate specimens and additional plant impressions were also collected from the same sequence of beds. The exact location of the various fossil localities is shown in figure 2, which is a portion of the Chisos Mountains Quadrangle of the U. S. Geological Survey. The area is approximately 10 miles NE. by E. of Pummel Peak, which is the northeastern spur of the Chisos Mountains.

A report on the geology of this general region was published by Udden,[1] who defined and named the formations exposed and established the Cretaceous age of the major portion of the sequence. Recent revision of nomenclature[2] has led to the following stratigraphic terminology:

Upper Cretaceous	
Navarro group:	Tornillo clay
	Upper Aguja formation
Taylor group:	Lower Aguja formation
Austin group:	Terlingua shale
Eagle Ford group:	Boquillas flags

[1] Udden, J. A., 1907, Bull. Univ. of Texas, No. 93.
[2] Adkins, W. S., 1932, Univ. of Texas., Pub. Bur. Econ. Geol., Bull. 3232, part 2, p. 271.

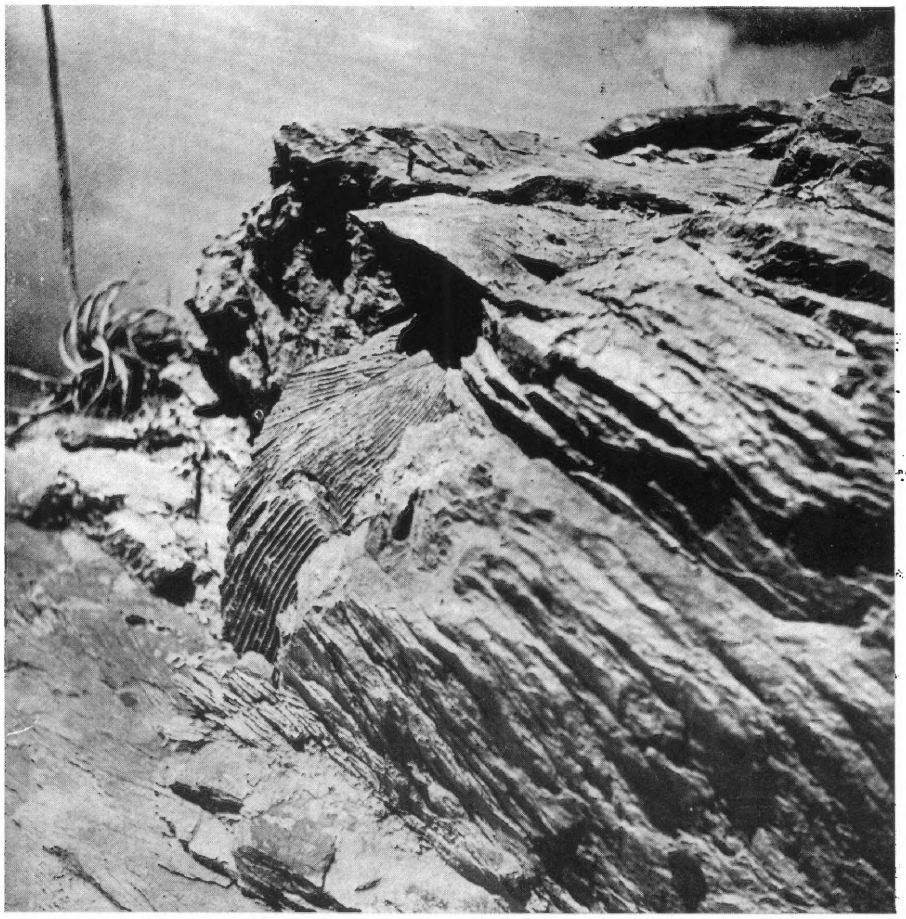

Fig. 1. Palm leaf impression in a ledge of sandstone (Locality 1) in the Aguja formation (G. D. Guadagni).

A somewhat generalized cross-section of the sequence, modified from a section furnished by Mr. Guadagni, is shown in figure 3. The line of the section runs roughly southwest from the Alto Relex scarp to the Banta Shut-in of Tornillo Creek. The localities shown on the section, which correspond to those of figure 2, have furnished the following fossil remains:[1]

No. 1.—Plants: *Sabalites ungeri* (Lesquereux) Dorf, n. comb.
Sequoia? *reichenbachi* (Geinitz) Heer

[1] I am indebted to Dr. Chester A. Reeds, formerly of The American Museum of Natural History, for the identification of invertebrate remains.

No. 2—Petrified trunks of trees
No. 3—Reptile bones: Cretaceous forms
No. 4—Invertebrates: *Inoceramus undulato-plicatus* Roemer
Mortoniceras cf. *delawarensis* (Morton)—(cast of interior)
No. 5—Invertebrates: *Inoceramus confertim-annulatus* Roemer
Exogyra ponderosa Roemer
No. 6—Invertebrates: *Exogyra* cf. *plexa* Cragin
Volutoderma texana (Conrad)—(cast of interior)

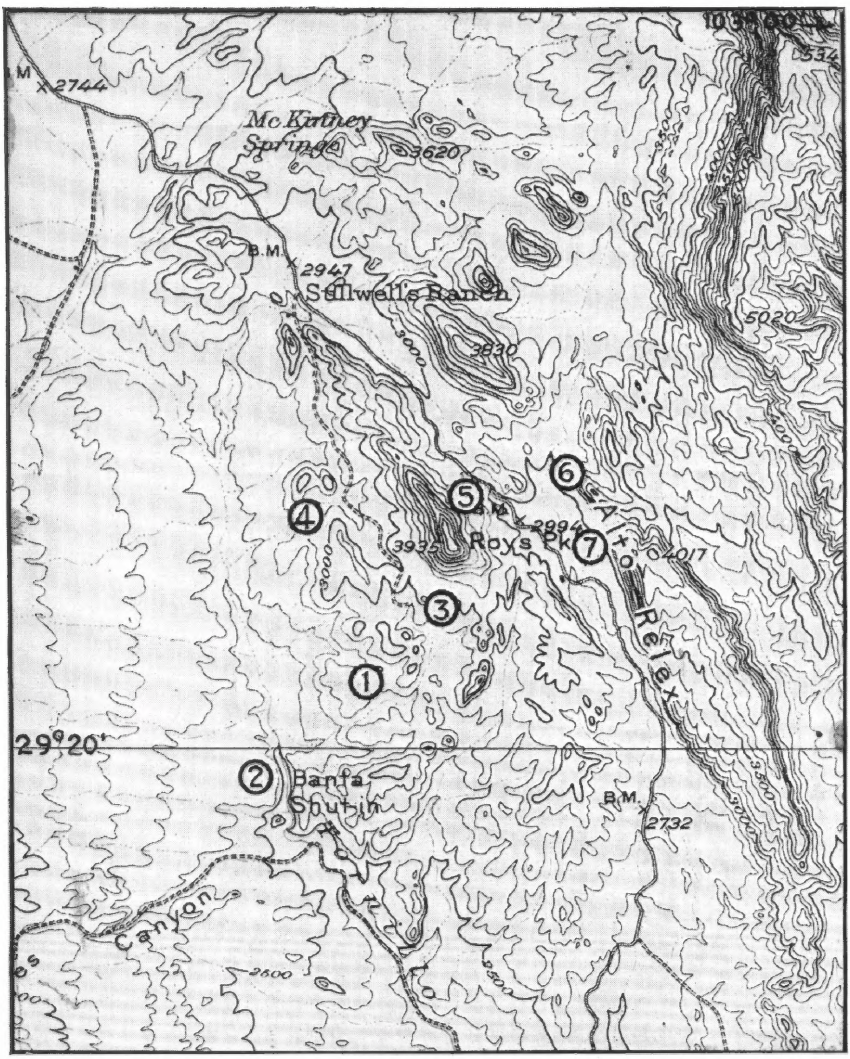

Fig. 2. Location of the area, showing position of localities (U. S. Geological Survey).

Hemiaster texanus Roemer—(somewhat crushed)
Turritella sp.—(cast of interior)
No. 7—Invertebrates: *Cucullaea* sp.—(cast of interior)
Holectypus planatus Roemer—(not complete)
Favia texana Cragin—(a fragment)
Volutomorpha cf. *ponderosa* Whitfield—(cast of interior)
Vertebrate: Cf. *Corax pristodontus* (Morton)—(shark's tooth)

The lithologic characters, sequence of beds and associated saurian bones, petrified stumps and leaf impressions make it rather certain that the upper part of the exposed sequence (Locality Nos. 1, 2 and 3) lies within the Aguja formation.[1] The inadequacy of some of the invertebrate specimens and the lack of detailed paleontologic work in this region make it impossible to state definitely the formational units represented in the lower portion of the section.

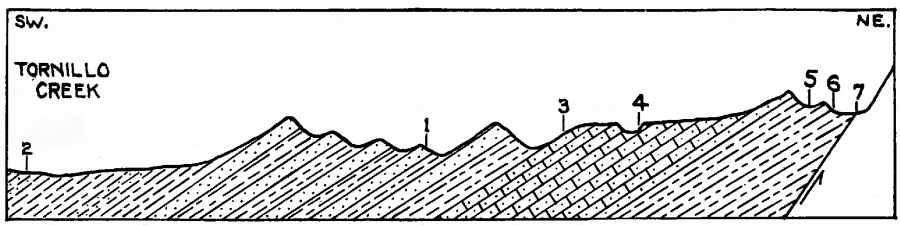

Fig. 3. Generalized section between Tornillo Creek and Alto Relex (modified from G. D. Guadagni).

ORDER CONIFERALES

Incertae Sedis

Sequoia? reichenbachi (Geinitz) Heer

Figure 4

Sequoia reichenbachi (Geinitz) Heer, 1868, Fl. Foss. Arct., I, p. 83, Pl. xliii, figs. 1d, 2b and 5a.—Knowlton, 1905, U. S. Geol. Survey Bull. 257, p. 157, Pl. xiv, figs. 3–5.—Hollick, 1907, idem, Mon. 50, p. 42, Pl. ii, fig. 40, Pl. iii, figs 4, 5.—Berry, 1914, idem, Prof. Paper 84, p. 23, Pl. iv, figs. 1–4; 1919, idem, Prof. Paper 112, p. 64, Pl. vi, fig. 2.

No. 25021, Amer. Mus. Nat. Hist.

Although fragmentary, the single specimen figured is sufficient to establish it as belonging to this widespread Cretaceous species. The synonymy given above does not include all the reported occurrences of *Sequoia reichenbachi*.[2] This species is in need of careful revision based

[1] Equivalent to Udden's Rattlesnake beds, see Udden, *op. cit.*, pp. 41 to 54.
[2] See Knowlton, F. H., 1919, U. S. Geol. Survey Bull. 696, p. 596.

on a restudy of type materials. It is unfortunate that the Aguja collection does not contain a larger suite of specimens showing the range of foliar variation and associated cone impressions.

The present specimen shows a slender twig with relatively short, falcate leaves, radially disposed. The leaves are somewhat wider than shown in the figure, which is a lateral, cross-section view. There is a resemblance to the foliage of *Geinitzia formosa* Heer[1] in which, however,

Fig. 4. *Sequoia? reichenbachi* (Geinitz) Heer. Natural size.

the twigs are thicker and the slender needles are interspersed with small, scale-like leaves.

Specimens referred to *Sequoia reichenbachi* are widespread both in Europe, Greenland and North America from the Lower Cretaceous through the Upper Cretaceous. The species has not been reported from the Tertiary. It appears to have been most abundant and widespread in Senonian and post-Senonian time.

The generic status of this species is in considerable doubt. Hollick and Jeffrey[2] have made an exhaustive study of both twigs and cones associated with foliage of the *S. reichenbachi* type in the Raritan formation; their conclusions indicate Araucarian affinities. Berry,[3] on the other hand, regards associated cones in the Black Creek formation as *Sequoia*-like. Seward[4] is of the opinion that a reference to the genus *Geinitzia*

[1] Heer, O., 1871, Schweizer. Paleont. Gesell. Neue Denkschr., XXIV, p. 6, Pl. I, fig. 9, Pl. II; Berry, 1916, Md. Geol. Survey, Upper Cret., p. 801, Pl. LIV, fig. 6; Knowlton, 1917, U. S. Geol. Survey Prof. Paper 101, p. 251, Pl. XXXI, figs. 1–3.

[2] Hollick, A., and Jeffrey, E. C., 1909, Mem. N. Y. Bot. Garden, III, p. 38, Pl. V, figs. 7–10, Pl. VIII, figs. 3, 4, Pl. XVI, figs. 2–4, Pl. XVII, figs. 1–4, Pl. XVIII, figs. 1–4.

[3] Berry, E. W., 1914, U. S. Geol. Survey Prof. Paper 84, p. 23.

[4] Seward, A. C., 1919, Fossil Plants, IV, p. 361.

would be more appropriate in view of the associated occurrence in the Raritan formation of cone-scales very similar to those of *G. gracillima* (Lesquereux) Jeffrey. In the absence of diagnostic cone materials in the Aguja collection it seems necessary, at any rate, to question the reference to *Sequoia.*

OCCURRENCE—Aguja formation, Tornillo Creek basin, Texas.

Family **Palmae**

Subfamily **Sabaleae**

SABALITES SAPORTA

Sabalites ungeri (Lesquereux) Dorf, new combination

Figure 5

Geonomites ungeri LESQUEREUX, 1878, U. S. Geol. Survey Terr. Rept., VII, p. 118, Pl. XI, fig. 2.

Sabal? campbelli NEWBERRY (in part), 1863, Boston Jour. Nat. Hist., VII, p. 515.

Sabal campbelli NEWBERRY. LESQUEREUX, 1878, Ill. Cret. and Tert. Plants., U. S. Geol. Surv. Terr., Pl. X.

Sabal grandifolia NEWBERRY (in part), 1898, U. S. Geol. Survey Mon. 35, p. 28, Pl. XXV, Pl. LXIII, fig. 5 (not Pl. LXIV, figs. 2, 2a).

Sabal? ungeri (Lesquereux) KNOWLTON (in part), 1917, U. S. Geol. Survey Prof. Paper 101, pp. 254, 289, Pl. LIX (not Pl. LVII).

HYPOTYPE.—Amer. Mus. Nat. Hist., No. 25022.

The single specimen figured has been compared with all available reproductions of Cretaceous and Tertiary palm leaves and with the type specimens of North American species at the U. S. National Museum. In a preliminary study of living palms and herbarium specimens at The New York Botanical Garden, I have examined hundreds of palm leaves in order to determine which of the leaf characters of palms can be considered most trustworthy for accurate generic and specific identification. The palmate or pinnate arrangement of the leaf rays has already served to distinguish in part the families and subfamilies of palms[1] and is the basis for the two main divisions: fan palms and feather palms, respectively. More specific characters which are, in my opinion, sufficiently constant and diagnostic to be useful in the identification of fossil specimens are as follows: (1) the character of the petiole: whether unarmed or armed with thorny spines, whether flat, convex or concave on its upper surface, whether or not it is prolonged into an acumen; (2)

[1] Drude, O., 1889, in Engler and Prantl, Nat. Pflanzenfam., II, div. 3, pp. 26–28.

Fig 5. *Sabalitesi unger* (Lesquereux) Dorf. One-sixth natural size.

the character of the acumen, if present: whether short, intermediate or long, whether its edges are straight, convex or concave; (3) the approximate number of rays in the leaf blade; (4) the depth to which the leaves are divided or cleft from the outer margin in toward the petiole.

In its observable, diagnostic features the present specimen can not be distinguished from those previously described and figured as the species enumerated in the above synonymy. Newberry was responsible for including in *Sabal grandifolia* the specimens which had been erroneously referred to *S. campbelli.* Knowlton subsequently recognized the similarity of *S. grandifolia* to the specimen previously described by Lesquereux as *Geonomites ungeri.* He accordingly synonymized all of these specimens and additional new material in the new combination *Sabal? ungeri.* One of Knowlton's specimens,[1] however, does not fit his description of this species and should undoubtedly be referred to his *Sabal inquirenda.*[2]

In view of the fact that there are 3 living genera whose leaf characters closely resemble those portions preserved in the fossil specimens it seems more appropriate to refer this species to the form-genus *Sabalites,* implying relationship to the subfamily Sabaleae rather than to the living genus *Sabal.* The new combination *Sabalites ungeri* may be redescribed as follows:

DESCRIPTION (Supplementary).—Leaves of large size, probably up to 2 meters in diameter, with 70 to 80 segments (rays) which are relatively narrow; petiole up to 5 centimeters wide, convex below; margins of petiole unarmed; petiole prolonged on the under side into a long attenuate acumen, extending into the blade of the leaf about one-third its length; tip of acumen continued into a false midrib from which upper leaf rays diverge; sides of acumen straight, curving abruptly outward at the top of the petiole; upper surface of leaf not known.

Among the numerous species of fan palms from the Upper Cretaceous and Tertiary of North America *Sabalites ungeri* is apparently closely related to *S. montana* (Knowlton) Dorf from the Upper Cretaceous of Wyoming and Colorado.[3] That species may be distinguished, however, by its shorter acumen, wider petiole and more numerous rays. There is also a resemblance to the Eocene species *S. grayanus* Lesquereux[4] which differs mainly in its smaller size, greater number of rays and basally enlarged acumen. Among European species *Sabalites ungeri*

[1] Knowlton, F. H., 1917, U. S. Geol. Survey Prof. Paper 101, Pl. LVII.
[2] Knowlton, F. H., idem, p. 288, Pl. LVI.
[3] Dorf, E., 1938, Carnegie Inst. Wash. Pub. No. 508, p. 47, Pl. III, fig. 2. Knowlton, F. H., 1917, U. S. Geol. Survey Prof. Paper 101, p. 253 (= *Sabal montana*), Pl. XXXII, fig. 3; 1922, idem Prof. Paper 130, p. 119, Pl. III, fig. 4.
[4] Berry, E. W., 1916, U. S. Geol. Survey Prof. Paper 91, p. 177, Pl. XII, figs. 1–3, Pl. XIV, fig. 1.

is intermediate in its characters between the Upper Cretaceous *Flabellaria longirachis* Unger[1] and the Tertiary *Sabal major* (Unger) Heer.[2]

Among living forms examined at The New York Botanical Garden the Texas specimen is comparable in observable characters to several species of the genera *Sabal, Livistona* and *Pritchardia. Sabal palmetto* (Walter) Roemer and Schultes of southeastern America and *S. deeringiana* Small of Louisiana possess leaves of essentially the same size, number of rays and petiole characters as in the fossil specimen. A close resemblance is also apparent in the leaves of the Asiatic *Livistona chinensis* Martius and *L. conchinchinensis* Blume, and of *Pritchardia pacifica* Seem., of the Fiji Islands. In the leaves of both species of *Livistona* the petioles are usually armed with thorny spines, a character not observed in the fossil specimen. On older leaves, however, the petiole is spineless up toward the leaf blade, precisely as in the fossil.

OCCURRENCE.—Aguja formation, Tornillo Creek basin, Texas.

[1] Unger, F., 1852, Inconographia Plantarum Fossilium, p. 91, Pl. XXXI, fig. 1, Pl. XXXII, fig. 1. Schimper, W. P., 1891, Traite de Paleontologie, pt. 2, p. 361.

[2] Heer, O., 1855, Flora Tertiaria Helvetiae, I, p. 88, Pl. XXXV, Pl. XXXVI, figs. 1, 2. Schimper, W. P., 1874, Paleontologie Vegetale, Atlas, Pl. LXXII, fig. 1. Saporta, G. De, 1866, Etudes, pt. 2. p. 77, Pl. II (= "*Sabalites major* (Heer) Saporta").